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THE NEEDS OF EDUCATION FOR UTILIZATION OF SPACE TRANSMISSION TECHNIQUES.

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STUDIES AND CONFERENCES WERE HELD ON NEEDS OF EDUCATION FOR THE UTILIZATION OF SATELLITE TV TRANSMISSION TECHNIQUES, TO DETERMINE THE ROLE WHICH EDUCATION MIGHT PLAY IN DEVELOPMENT AND TO PREDICT FUTURE NEEDS. RESULTS OF THESE STUDIES AND CONFERENCES HAVE BEEN REPORTED FOR AN ORGANIZED LOOK AT THE DEVELOPMENT OF SPACE COMMUNICATION, ITS APPLICATION TO EDUCATION, AND ITS POTENTIAL FOR EXPANDED EDUCATIONAL USE THROUGHOUT THE WORLD. (LP)

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THE NEEDS OF EDUCATION

FOR

UTILIZATION OF SPACE TRANSMISSION TECHNIQUES

A Report

on the Space Satellite Communication Program

as It Affects Education

By
THE NATIONAL ASSOCIATION OF EDUCATIONAL BROADCASTERS
1346 Connecticut Avenue, N.W., Washington, D.C.

In Cooperation with
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PREFACE

In 1961 the report of the Survey of the Needs of Education for Television Channel Allocations revealed the broad implications of television in the future educational program of the United States. Before this survey was completed, it became evident to the National Association of Educational Broadcasters, and to the U.S. Office of Education, that another study was necessary to determine the implications which the rapid advance of space satellite communications might have for education. A survey was authorized and planned to study the needs of education for the utilization of space transmission techniques, and to determine, if possible, the kind of role education might play in this development, and the kind of action which might be necessary to provide for the future needs of education in the space satellite communications program.

The engineering firm of Jansky & Bailey was called into consultation with the NAEB research team. An engineering study was made of the present developments in space satellite communications in terms of the potentialities such developments might have for educational purposes. The current literature was studied extensively. Conferences were organized at various educational centers throughout the country to discuss the engineering developments in the field, and the needs of education which might be satisfied in the future by the application of these developments to educational communications. Various national educational agencies were contacted regarding the possible involvement of the educational community in the space satellite program.

The results of these studies and conferences have been compiled into this report in order that there might be an organized look at the development of space communications, its application to education, and its potential for the expansion of educational opportunities in the world. The attitudes of a large sampling of educational authorities as to the need for current action in regard to possible future uses were assessed.

It should be recognized that this report is comprehensive, but it is not exhaustive. It is presented as an instrument which might make it possible for educators, and for government officials and legislators to get a better perspective of the problem as it relates to education in all areas on both a national and an international basis in the next ten to twenty years.

In the course of this study, conferences and discussions were held at the following institutions and centers:

Purdue University
Auburn University
Georgia Institute of Technology
University of Nebraska
University of Georgia
Ohio State University
Institute for Education by Radio and Television
D.A.V.I. Television Conference, Kansas City
Brookings Institution

In addition to the references cited at the back of this report (under "Footnotes" and "Bibliography") the following agencies were consulted:

National Aeronautics and Space Administration
U.S. Department of State, Telecommunications Division
Telecommunications Management, Office of Emergency Planning
Inter-Departmental Radio Advisory Committee
Federal Communications Commission
Joint Council on Educational Broadcasting
Southern Regional Education Board
National Education Association
Learning Resources Institute
International Radio Consultative Committee

Editions of the following for December, 1961, through March 15, 1962, were reviewed to keep up to date with space activities:

National Observer
Wall Street Journal
Electronic News
New York Times

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INTRODUCTION

Artificial earth satellites as distance boosters for communication purposes will soon become a major means of global or trans-oceanic communications. An operational satellite-based voice communications system for telephony is scheduled to start in 1965, and within ten years both telephony and radio will depend heavily upon this new system. Television, facsimile, and other data transmission will follow rapidly.

It is estimated that an operational television system will be possible in the year 1968. The activation of this tremendous advance in transcontinental, or global communications will begin in the late spring or early summer of 1962 when the United States will launch several types of telecommunications satellites, which will differ in the natures of the relay system, the characteristics of the orbit, and the frequencies to be used.

The first of these satellites to be launched for beginning experimentations in this method of boosted or extended communications is the "Telestar," which is being prepared by the American Telephone and Telegraph Company and will be launched by the National Aeronautics and Space Administration.

This satellite will be orbited in such a way that during each of its revolutions (it will take approximately 2-1/2 hours to circle the earth) there will be a usable period for telecommunications of between 5 and 15 minutes. This will occur during the approximate 25 minutes of the 2-1/2 hour cycle when the satellite is visible from both the United States and Europe.

Probably the Radio Corporation of America, and other companies working with the National Aeronautics and Space Administration, will put other and different types of satellites into orbit later in the year.

The projected use of satellite communications is considered commercially necessary because of the predicted increase of intercontinental telephone traffic, which will demand more voice channels than can be economically provided with the present type of equipment. In addition to this, the expected rapid development of presently underdeveloped nations in the world will create communication demands which can best be initiated and expanded by way of space satellites. It is felt that this will be particularly true in relation to the southern hemisphere.

Current efforts in space indicate that within the next ten years communications will become dramatically changed, making impressions upon and greatly affecting the status of global educational, social, and economic concepts. Before the year 1985 the technological advances in space will become of such magnitude that they are expected to noticeably change the way of life of all nations in varying degrees. This will occur both as a direct result of space exploration and communications, and because of the by-products of this effort. How the world reacts to the electronic space revolution in the nuclear age will depend a great deal upon education, propaganda, balance of world power, and the public relations efforts of the interested groups, commercial companies, and participating nations.

In the light of our present knowledge, there is unfortunately one major inhibition to the total development predicted in space satellite communications. That inhibition is

the natural limitation of the electromagnetic spectrum. There is only one electromagnetic spectrum, and it is finite and uniformly distributed throughout the universe. This simply means that it is in the public domain of all nations, and that no nation has a monopoly or a priority on it. That portion of the spectrum which is adaptable to communications is limited, and while it is true that year by year we are learning to control and to use effectively radiations in the higher frequencies, there is no assurance that we can continue to extend the useful range of the radio spectrum indefinitely.

Because of this fact of the radio spectrum, all telecommunications services in the world must use the frequencies available, and use them in a manner that will not interfere with other services. This means that the usable radio spectrum as it exists today has been allocated by international agreement into various areas of use, and it means that the frequencies which will be used in the future for space satellite communications will also have to be allocated by international agreement.

At the present time there are some 108 nations which belong to the International Telecommunications Union under the United Nations, and it is reasonable to suppose that a number of the newly created nations in the world will increase this considerably.

At the 1959 conference of the International Telecommunications Union there was an agreement to allocate twelve frequency bands to space communications for research purposes, to be used by the participating nations on a sharing basis; and one channel was set aside for radio astronomy. However, it is obvious that with the rapid increase in communication satellite technology the twelve frequency bands allocated for research purposes will not suffice for operational purposes and for the continuing research necessary in this field.

At the 1959 conference, the International Telecommunications Union recognized the possibility of inadequate frequency assignments for space communications when it recommended that another Extraordinary Administrative Conference be held late in 1963 to examine the technical progress made in space communications in the meantime, and to decide, in the light of such examination, the allocation of frequency bands which would be necessary for the various categories of space radiocommunications, and to determine the kind of precautions necessary to protect the use of such frequencies.

In the United States the determination of a policy relating to this country's position before the 1963 Extraordinary Administrative Conference is determined by a rather complicated process--principally because so many different interests are involved. The final approval of the United States position, and the presentation of this position to the conference is the responsibility of the U.S. Department of State. This is usually handled through the Telecommunications Division of the State Department. However, the details of the position of the United States in these matters are worked out jointly by the representatives from the Federal Communications Commission and the Inter-departmental Radio Advisory Committee, which represents the interested agencies and is directly responsible to the President's office for advice on all governmental use of radio frequencies. (Early in 1962 the Inter-departmental Radio Advisory Committee was superseded by the appointment of Dr. Irvin Stewart as Director of Telecommunications Management in the Office of Emergency Planning, which is a part of the President's office. Dr. Stewart will be responsible for making decisions in the area of governmental use of frequencies in conjunction with the Federal Communications Commission; however he has indicated that the Inter-departmental Radio Advisory Committee will continue to function.)

Represented on the Inter-departmental Radio Advisory Committee are the government departments and agencies directly concerned with the use of frequencies--the Justice Department, the State Department, the Army, the Navy, the Air Force, the Federal Aviation Authority, the National Aeronautics and Space Administration, the Department of Agriculture,

the United States Information Agency and the Department of Interior. Of course, the Federal Communications Commission is represented on IRAC because it regulates the use of radio frequencies and in some ways makes use of frequencies.

It is important to note the agencies which are not represented on this committee, and which have no hand in the determination of government policy in over-all use of frequencies allocated to government, or in such international agreements as may be negotiated. The most notable of these omissions, as far as this report is concerned, is the U.S. Office of Education, Department of Health, Education and Welfare. In discussing this omission with some government administrators it was pointed out that until recently the Department of Health, Education and Welfare was not directly concerned with the use of frequencies, and therefore had no logical place on IRAC. However, with the passage of the Magnuson-Roberts bills and the availability of some $32,000,000 to the educational community of the United States for the construction of broadcast stations, through the Secretary of Health, Education and Welfare, it seems the involvement of this Department in governmental policies which will in any way affect or modify the allocation of radio frequencies is increasingly significant.

A beginning was made on the formation of an official position for the United States at the 1963 Extraordinary Radio Conference when the joint meeting of the FCC and the IRAC issued a report of their findings on September 7, 1961, entitled PRELIMINARY VIEWS OF THE UNITED STATES OF AMERICA ON FREQUENCY ALLOCATIONS FOR SPACE RADIOCOMMUNICATION.

In the introduction to this report it was stated that "studies of the world trend in telecommunications requirements, and the known plans for expansion of existing telecommunications facilities throughout the world have repeatedly indicated that, beginning about 1965, the loading of these facilities will approach saturation in many areas . . . also the matter of congestion in the high frequency spectrum has concerned the members of the International Telecommunications Union for many years. There is no foreseeable reduction in the use of high frequencies for global communications. On the other hand, expansion of service in the high frequency bands will become increasingly impracticable. Accordingly, it becomes necessary to seek alternative means to satisfy the growing telecommunication needs of the peoples of the world, including those of new or developing countries. Global communications via earth-satellite relays promises to afford such an alternative, which will be required beginning about 1965."

The September, 1961, report estimated that about 3000 megacycles of spectrum space would be needed to meet the foreseeable requirements until 1970. It is suggested that these 3000 mc be established in the frequencies between 3700 mc and 8400 mc.

The report established the following uses for space radio-communications:

A. Aeronautical mobile
B. Broadcasting
C. Meteorological
D. Navigation
E. Space Research
F. Communication Relay (both passive and active)

It is in the area of category "B" and category "F" that education must be specifically concerned in the years ahead. Category "B" of course would deal with the potential of

direct satellite-to-home or school broadcasting. While this is, at the present time, considerably in the future, and has no practical place in the immediate planning of broadcasting facilities, it is nevertheless a real potential that must be considered by education in asking for consideration in the future use assignments of satellite facilities.

Category "F" is a more immediate concern, because these are the space satellite facilities which will be first available to us. (The details of the present development of the space booster are discussed later in this report.) The fact that the various governmental agencies and departments involved in the use of radio frequencies recognize the shortage of available frequencies, in terms of the potential use during the next 10 to 15 years, and the urgency for making provisions for such services as will be involved is significant to the educational community.

Later in the year of 1962 another joint committee from the Federal Communications Commission and the Inter-departmental Radio Advisory Committee, with Dr. Irvin Stewart, will be brought together to analyze the reactions received from other members of the International Telecommunications Union on the preliminary views expressed in the 1961 report, and to finalize the details of the American position for frequency allocations at the 1963 Administrative Conference of the ITU.

It would seem reasonable, and in keeping with the previously noted developments, that this would be the time for education, through the Department of Health, Education and Welfare, to be represented on the planning committee, through membership in the Inter-departmental Radio Advisory Committee.

This joint committee of the FCC and the IRAC under Dr. Stewart will certainly not discuss specific program assignments for satellite communications nor make any such recommendations to the ITU. However, it is important, in determining the bands of frequencies to be allotted to each of the six categories of use, that consideration be given in categories "B" and "F" to the fact that education will need and use a portion of these frequencies in the future. This indication of need in the conference to determine the American position may well affect the determination of the range of frequencies to be allotted in the several categories.

Study Group No. 4 of the International Radio Consultative Committee, concerned with the scientific aspects of the use of the spectrum, (CCIR of the International Telecommunications Union) met in Washington in March, 1962, as a further prelude to the 1963 International Conference. This study group does not concern itself with frequency allocations, but with problems surrounding such allocations other than those of a political nature.

At this conference it was unanimously agreed that the membership conduct further studies on the use of frequencies above 10,000 megacycles as there was good evidence to indicate that these higher frequencies would be in increasing demand if they could be properly controlled and used. It was also agreed at this conference that satellite communications systems could physically share the same spectrum space as ground-based microwave systems, provided there was a reasonable spacing between the ground-based satellite receivers and the microwave systems.

This, in effect, suggests to the 1963 International Conference that the use of the spectrum may be considerably enlarged without getting into the higher frequencies which are now beyond adequate control. In many ways perhaps this would make possible the easing of some of the conflicts between the service categories, and ease some of the political problems which might arise from the shortage of available frequencies.

Any increase in the scope of use of the available frequencies as suggested by the

study group of the CCIR in Washington is encouraging to the future educational use of intercontinental television transmission via space satellite boosters.

In a report which was prepared by United Research, Inc., for the National Aeronautics and Space Administration, it was stated:

"The setting aside of radio frequencies for communication satellite use has been hampered to date by an inability to specify clearly and convincingly the frequency needs. Specific guidance will be required in preparing for the next round of international radio conferences. . . . This information will be helpful in deciding which blocks of the spectrum should be set aside for the eventual use of the communication satellite system. If a valid basis for decision can be construed before all channels are allocated or licensed, troublesome legal and practical problems relative to 'recapture' of channels from other microwave users can be avoided."

In commenting on this, on the floor of the Congress, Senator Magnuson called attention to the needs of education and the potential of educational development through the use of television and the extension of television by space satellite boosters.

The Senate Committee on Aeronautical and Space Sciences issued a report, "Policy Planning for Space Telecommunications," in which it was stated:

"At present many African nations cannot communicate with each other directly, but must rely on radio or cable circuits involving relays through London or other European cities. These new nations are certain to desire independent communication systems as part of their programs of self-government. A single space relay over Africa has entertaining possibilities as a link between all African nations, and may prove attractive regardless of purely economic consideration.

"It is interesting to note that such nations as Ghana and Nigeria are making substantial capital investments in domestic television stations which superficially would appear beyond their economic and perhaps out of keeping with the level of technical and cultural development.

"On the other hand television has an unparalleled potential for mass education and one can imagine at least that this was a major factor in the decisions by these nations to move ahead technologically without any of the intermediate steps which other nations employed in their technological advancement.

"If domestic television is promoted among all of the newly emerging nations there will be an unparalleled opportunity to familiarize the peoples of these nations with events around them through international television broadcast. Radio is already being employed very heavily by the United States and Soviet Russia in the ideological struggle for the minds of men in these countries. Artificial satellites may offer a technique by which the even more effective medium of television could be similarly employed."

It is evident that the practical development of communication satellites has been achieved, and that the use of these facilities for intercontinental and transcontinental and inter-hemispheric transmission of communications of all kinds is only a matter of a short time. It is equally evident that the political and sociological developments in the world will place an increasingly large burden upon the forces of both formal and informal education, and that every means must be used to extend and amplify the existing educational resources throughout the world.

There seems to be little doubt that if the educational services are not provided for

in the initial planning of these new facilities, they may well be deprived of the effective use of this development at a time when the demand for educational communications will be greater than ever.

It would be very difficult to attempt to specify the number of frequencies or the particular frequencies that ought to be provided for education in the satellite system, but it is not unreasonable nor unrealistic to insist that education be represented in all considerations involving the use of this new technology.

SATELLITE SYSTEMS

There are five types of satellite systems for communication purposes in use and under development. These are:

1. Nonsynchronous passive satellites
2. Nonsynchronous active satellites
3. Synchronous passive satellites
4. Synchronous active satellites
5. A combination of any two or more of the above.

Synchronous satellites are those which have orbital altitudes approximately 22,000 miles above the earth's surface, and which rotate around the earth once every 24 hours, so that in essence they remain "motionless" above a given point of the earth. Nonsynchronous satellites are those whose orbital altitudes are less than 22,000 miles above the earth's surface, and which rotate around the earth more than once every 24 hours.

Space satellites are either passive or active: the moon is an example of a passive satellite in that a signal can be "bounced" off its surface. An active satellite has receiving and transmitting equipment; thus it receives an aimed signal from earth and retransmits this to another spot on earth, after frequency change and amplification. The active satellite requires less transmitting power and less sophisticated receiving stations than those for the passive satellite. However, the passive satellite contains no electronics and has none of the problems of spaceborne equipment.

Synchronous satellites have two advantages. One such satellite would be within the line of sight of nearly half of the earth's surface at any given time. Three properly placed satellites would provide almost complete global coverage at all times. The synchronous satellite is easy to locate, simplifying the problem of properly pointing ground station antennas.

Disadvantages of synchronous satellites are: launching requirements to put a given payload in a 22,000-mile orbit are greater than for placing the same payload in a lower orbit; the power required to transmit signals between earth-satellite-earth is greater than for a lower orbit satellite.

Nonsynchronous satellites require expensive and highly accurate ground tracking equipment, are within line of sight of a limited area at any given time, and consequently require more than three (as in the synchronous orbit) satellites to provide complete global coverage at all times. However, nonsynchronous satellites require less expensive transmitting and receiving equipment, and if enough of them are put into orbit for a communications system the tracking problem decreases.

Echo and the moon are passive satellites; Tiros and Courier are active satellites.

The utility of satellites for communications, both civil and military, is based upon

economics. Today it is more economical to tape commercial television programs and use jet airplanes for fast delivery world-wide than to set up a satellite relay system to accomplish the same objective. Other methods for relaying signals over long distances include high-frequency radio; VHF or UHF wireless communication using land-based, shipborne, or airborne relay stations; transmission lines and cables (including submarine cables); and tropospheric, ionospheric, or meteorburst scatter propagation.[1]

Satellites as communications boosters can compete with other methods because: they can be launched quicker than it takes to complete extensive long-distance ground communications systems; satellites can cover wide areas using a multiplicity of interconnected ground transmitters; they can pick up messages transmitted straight up and rebroadcast them straight down at the intended reception point even if that point is moving, as on a ship; and lower power levels can be used throughout, and interference among neighboring stations on the same frequency eliminated, thus greatly increasing the number of usable channels in a given region of the radio-frequency spectrum.

An active satellite can be controlled so that only the intended message is transmitted; a passive satellite can be used by anyone desiring to bounce off a signal. Active satellites can be "jammed" easier than passive ones, yet active satellites can be multipurpose and carry a greater number of voice channels (600 two-way channels at a minimum).

PROPOSED SATELLITE SYSTEMS

Transoceanic communication facilities with broadband capabilities will be provided by space satellite communications through the use of active satellite relay stations. These will include: television, facsimile, real-time transmission of large-scale business computer data, and hundreds of high-quality radio-telephone channels, together with increased capacity for telegraph, radio, and teletypewriter.

The use of satellites as communications links is important to currently underdeveloped nations where it is cheaper to install a relatively inexpensive transmitting-receiving station than to install current equipment, thus giving said areas direct communication with any country in the world that is also using the satellite link. In Africa, Asia, and South America, intracontinental communications systems could be established more quickly, more economically, and with less technical difficulty with space communication systems than through the use of land lines or microwave links.

Replies to FCC Docket of Inquiry No. 13522 by industry resulted in a near-unanimous agreement that a voice communications satellite system was not only technically possible, but would be a sound business investment as well. The use of satellites as distance boosters for television relay and broadcast was considered difficult and premature in light of the current state of the art, but not impossible and certainly possible on a commercial basis by the middle 1970's.

For the immediate future, voice communications satellite systems were considered feasible, and their relation to television discussed as a potential. Some views of industry, private individuals, and foreign writers are recorded in the following:

(The basic views of Lockheed are detailed in the next Chapter, as they are fairly representative of the views of industry.)

Lockheed based its technical position on 329 hours (as of March 1, 1961) of earth-space-earth communications conducted by that company. They conducted a study of the economic and technical feasibility of a commercial voice satellite telecommunications system to determine whether such a system would be a feasible venture for private enterprise. As of March 1, 1961, Lockheed concluded:[2]

1. An international satellite communications link for telephone, telegraph, and telex communications by private enterprise is economically feasible by 1966-1968, and technically feasible before that.

2. Only one commercial (not including military) voice satellite communications system will be feasible insofar as the U.S. is concerned due to economic, technical, legal, and political considerations.

3. Such a system would probably be best operated by a common carriers' carrier, open to equity ownership, and open to use by other U.S. authorized international

voice or record carriers not electing to participate as part owners.

4. A satellite link would provide channels to all voice and record carriers in the U.S. and abroad engaged in international communications and these would originate and terminate via the land distribution networks of existing carriers.

5. The FCC would regulate the common carriers' carrier, termed Telesat.

Lockheed said their actual channel use included Agena satellite experience of 24 launchings, 242 channel-hours space communications, using "S" band region as well as VHF; Polaris ballistic, 85 launchings with 87 channel-hours of space communications, mostly on frequencies below 1,000 mc, with some around 5,000 mc; Lockheed Space Laboratory conducted theoretical calculations over three years on space communications problems including from 1,000 mc to 300,000 mc, and vehicles now being designed by Lockheed have multiple communications links at above 1,000 mc.

Lockheed favors a synchronous satellite communications system as the most economical and practical.

General Electric[3] suggests that a satellite relay system be based on nonsynchronous equatorial orbits, with 10 satellites equally spaced around the earth, at an altitude of 6,000 miles. This should provide: single channels (for special purposes), 12-channel groups, 300-channel master groups.

The bulk of traffic would flow in master groups, but the majority of the terminal stations would use single channels or 12-channel groups for traffic originated by them. Recommended capacity per satellite is: By 1970—1200 channels and by 1980—6000 channels.

Frequency allocations should be made to share the fixed and mobile bands around 4,000, 6,000, and 8,000 mc, plus in some cases the band around 12,000 mc, with a maximum wide bandwidth of 1,500 mc.

General Electric recommends specifically: for small traffic areas, exclusive allocations of 10 mc width in the range 1,000-2,000 mc, based on single-sideband or double-sideband AM techniques; for high traffic areas, shared allocations to the extent of 500 mc immediately and 1,000 mc additional by 1970-1980, divided into bands of 4,000, 6,000, and 8,000 mc on wideband FM techniques.

General Electric predicts the primary uses of communications satellites from 1965 to 1970 will be in the areas of telegraph relay, graphic relay, and telephony relay; secondary uses, but still important, will be data relay and television relay. Television broadcast will not be used up through 1970, and there will be small use of AM/FM broadcast. The appearance of multipurpose satellites would mean that data relay and television relay would become primary uses and AM/FM broadcast a secondary use; television broadcast would have small use. A multipurpose satellite would be used for research, geodetic, and communications purposes, for example.

General Electric also spelled out what the company considers the requirements for global television via satellite relays into conventional, home receivers. This is based on the U.S.A. standard, assuming use of the band 470-890 mc, and a network of three synchronous satellite stations. Each satellite would include one or more general coverage channels to furnish a "B" level signal to the entire visible part of the earth. The transmitter would have a power of 35-50 kw, and the antenna would have a beamwidth of 17^{o} and a diameter

(for 8,000 mc) of six feet. Each ground station would have two larger antenna systems, one for "A" level coverage to northern industrial areas, the other to southern areas. Each of these would consist of a single large reflector, about 25 x 35 feet in size, with multiple feeds; three transmitters per large dish should give ample coverage. The equipment at each satellite would amount to seven video transmitters and seven aural transmitters, with a total power output of 700 kw.

The General Electric Company has indicated that it believes that power technology will provide a source of 1 megawatt from an orbiting satellite by 1970.

Radio Corporation of America, in an article in Electronic Age, Vol. 21, No. 1, 1962, describes processes of energy conversion that proceed from heat or light or chemical energy directly to electrical energy without mechanical aid. The solar cell used in satellites today is an example, and solar cells are expected to produce an output of 300 watts on a 1-1/2 ton observatory satellite in 1963.

RCA terms these processes the photovoltaic process in solar cells; the thermoelectric effect which produces electricity directly from any type of heat source up to about 1800°; and thermionic conversion which generates electricity from heat in the 2000° to 4000° range by means of a gas-filled tube that is similar in principle to the high-power electron tubes used in broadcast transmitters. RCA expects these processes to provide the needed power for space flight and satellite repeaters.

Specific General Electric Considerations:

1. Satellite TV broadcast operated from the synchronized orbit.
2. Preferred station locations are:

Area	Location, Equator at
Americas	100° west
Europe-Africa	30° east
Asia-Australia	120° east

3. Make provision for three general coverage channels providing B-grade service—more channels may be desirable.

4. Make provision for 18 limited coverage channels, serving areas of high population density—more channels may be desirable (these could be shared).

5. Exclusive allocations are needed due to the susceptibility of TV signals to interference.

6. A world-wide TV standard should be adopted.

7. The band 470-890 mc (or a part of it) is suggested.

8. The service should be considered as a supplement to current techniques.

All of this indicates that there seems to be small chance of a communications satellite being developed for general television broadcasting in the foreseeable future; but it does indicate that intercontinental television relay systems are feasible and will probably become practical within the next decade.

In computing the cost of a voice communications satellite system, General Electric estimates that cables versus satellites compare as shown below. (Add $320,000 to the $283,000 before the first profitable year.)

	One Route Two Terminals	Worldwide Route 18 Terminals
Satellite	$247,000 Investment	$283,000 Investment
	27,000 Average Annual Operating Expense	33,000 Average Annual Operating Expense
Cable	$ 31,000 Investment	$472,000 Investment
	1,000 Average Annual Operating Expense	27,000 Average Annual Operating Expense

In contrast, U.S. News and World Report, February 12, 1962, reported:

"Some experts now say that a single satellite costing about 40 million dollars will carry as much traffic as a cable system costing 500 million. It was suggested that tax revenues from a satellite network, according to some authorities, could help defray the expenses of many other space programs."

Brig. General David Sarnoff, Chairman of the Board of RCA, stated in an advertising tabloid of Federated Purchaser, Inc., published by the New York Times on Sunday, February 11, 1962, that the international communications business of all American carriers today amounts to about $135 million a year. In the 1970's, he predicted, with a satellite system in use, operating revenues may reach the one billion mark.

OPERATING COSTS

Satellites might provide cheaper communications per channel than submarine cables and might be economical for all but short links if the number of channels is large enough, according to S.H. Rieger, Rand Corporation, Santa Monica, California.[4] This is probable despite the pessimism as to reliability and launch costs. Rieger predicts continued growth of transoceanic channels, noting that such traffic tripled in the last ten years, and sees no reason for the trend not to continue.

It will be a long time, however, before satellite communications can economically compete with microwave relays in conventional overland applications, he points out.

Operating costs of communications satellite systems will include ground terminals, satellite replacement, research and development work, and normal service; these added costs from conventional submarine cable operation must be amortized by an increase in traffic over present volume.

Hughes Aircraft Co. has estimated the cost per launch of a satellite system[5] at $6 million with a probability of 0.64 that the satellite will successfully orbit. For an average satellite life of 40,000 hours (four and one-third years), the first year's cost would be $45.6 million; the cost for a satellite with a reliability of 200 hours between failures is $1.7 billion per year. The 200-hour mean time between failures is according to reliability levels for airborne communication equipment with a complexity comparable to that of electronic equipment used in a satellite system.

This means there must be improvement of 200 times between current communications equipment and the reliability required of essentially the same equipment, circuits, and functions enclosed in an orbiting, nonmaintainable satellite. These problems show the great amount of research and development work still to be done to make a satellite system economically competitive with submarine cables. This gives one yardstick of measure when thinking in terms of using this form of communications medium.

At this point it is of interest to note the requirements spelled out by A.T.&T.[6] if a synchronous satellite transmitted television to home-type receivers today. The table below is taken from a report in Broadcast Engineering, October 1961.

Area Served	USA
Frequency (Channel 52)	700 mc
Satellite Height (Synchronous)	22,300 miles
Modulation	Vestigial Sideband, AM
Satellite Antenna (10 Ft.) Gain	25 db
Ground Receiving Antenna (5 ft.) Gain	18 db
Ground Receiver Noise Temperature	3000° K
Ground Receiver Noise Figure	10.5 db
Peak-to-Peak Signal to RMS Noise at Baseband Output	37 db
Satellite Transmitter Power	60 kw

The satellite repeater output being designed by Bell Laboratories for the A.T.& T. experiments is two watts. The above table calls for 60,000 watts, thus showing the tremendous difference today between what is possible and what is practical.

A.T.& T. states that a satellite broadcasting station should be put out on a signal that can be received on ordinary home receivers (this is a future, commercial goal), meaning the use of a synchronous satellite at 22,300 miles altitude and with the transmitting antenna having no more than 25 db gain in order to cover the area of the United States.

The problems are enormous, representing the difference between transmitting to a home receiver and transmitting to a 60-foot horn antenna with a 20-degree Kelvin maser receiver; or a $150 receiver and one costing approximately 10,000 times as much.

Satellite capabilities today do not make it possible to broadcast worldwide educational TV into areas that are not equipped with a network of broadcasting stations and special, relatively expensive receivers. They permit reception at one point (say, Turkey for middle Europe) with an expensive and complicated receiver that would be justified if there were a network to be fed. This also applies to the use of satellites for telephony where the areas do not have a good terrestrial network.

A.T.& T. believes, however, that satellites will bring intercontinental commercial TV, on a paying basis, to those areas which have local broadcast stations; they will also provide expanded high-quality circuits into areas where there are ground networks to connect to.

At the IER International Convention in New York on March 29, 1962, Richard G. Gould of the Stanford Research Institute presented a paper in which he said, among other things:

"It seems clear that hemispheric TV broadcast from a satellite cannot be justified solely on the basis that it will provide instantaneous transmission of programs. Moreover, the problems of different transmission standards, language, and wide differences in local

time make a hemispheric system, from the standpoint of programing, extremely inefficient and uneconomical. Even if the transmitting antenna pattern could be shaped to cover only the desired service area, the required primary video transmitter power would be 300 kw on a VHF channel and 795 kw on a UHF channel. Both are greater than even the 60 kw available from the proposed SNAP 8 nuclear power source, and do not include power requirements of the aural transmitter, the aural and video receiver and any control units.

"Video power requirements for coverage of smaller area are proportionately less, and might conceivably be supplied by one of several proposed SNAP units. Such service might be justified on the basis of lower cost than a network of ground TV transmitters connected by a microwave or coaxial cable networks. However, the calculations for required transmitter power are extremely generous in all of the arbitrary assumptions: average rather than minimum receiver noise figures were used; line losses of new, dry, transmission line were used; a minimum signal-to-noise ratio was assumed, and so on. For coverage of the United States, the SNAP 8 power source might conceivably supply sufficient power for a video transmitter on a VHF channel, but many existing stations would have to be displaced to make one channel available. With a source of power of about 40 kw, video coverage of either Brazil or Argentina is possible on a VHF channel. An additional antenna, or an antenna rotator/elevator, must be furnished by the set owner if both the satellite and existing ground transmitters are to be received. On any of the UHF channels, the set owner must purchase, install, and operate a UHF converter.

"If multiple audio channels are to be supplied, a modification to existing broadcast standards must be made and equipment designed, manufactured, sold and installed to implement this new service.

"It should be emphasized that it is the direct hemispheric TV broadcast aspect which is considered fantastic. The use of communications satellites to relay television programs between and across continents is a desirable and achievable goal. In this case, programs received at the satellite system terminal would be fed into the TV networks within each continent or area for immediate or delayed broadcast by local TV stations.

"The space age appears to offer promise of providing new services and performing present tasks in novel ways. One criterion of this age should be that the new services must be necessary and the novel methods of providing an existing service should produce results that are at least as satisfactory as the method being replaced. Thus a TV broadcast system providing less than 40 db or so of signal-to-noise ratio, and based on averages rather than minimum (thus providing marginal service) is no real advance or improvement. Moreover, the installation of a system for which there is no need is an extravagant and unnecessary demonstration of technical competence."

An example of systems being proposed for space satellite communications is that described by Alfred P. Martin, Westinghouse Electric Co., Baltimore, Md.[7] which would use the microwave regions from 20 to 80 kilomegacycles. Three synchronous satellites in equatorial orbits 22,300 miles from earth, spaced 120 degrees apart, would be repeater satellites using frequency translation techniques to direct communication intelligence to a desired point. The satellites would have harmonic frequency doubler and traveling wave tube multiplier-amplifier chains, subharmonic variable reactance demodulators and TWT amplifier chains, and externally programed antenna and tracking servo systems. The satellites would be repeater-translators directing the radio energy along its proper propagation paths by means of frequency ciphering techniques, eliminating the need for oscillators.

L.F. Mathews (of Associated Television, Ltd., London, W.) writes in the October, 1961, Journal of the British I. R. E.[8] on television communications using earth satellite vehicles. Major problem areas have been summarized here from his paper.

There are two types of orbit for a satellite under consideration, but both present advantages and disadvantages that are of such importance that a compromise orbit is suggested by Mr. Mathews. Considerations are: economics of launching a satellite and the size of rocket to be used; land area to be covered at any one time; size and complexity of ground equipment; and size and complexity of satellite equipment.

In order to blanket the world with TV coverage twenty-four hours a day three satellites in a circular equatorial orbit would be required, at 22,300 miles above the earth. This would make them synchronous satellites in that they would orbit the earth once every twenty-four hours, and if they followed the same path of the earth's rotation, they would remain effectively stationary with respect to the earth. Getting satellites to this altitude requires an expensive grouping of rockets and additional controlling equipment on the satellite to maintain its period and altitude correctly with respect to earth. Also, signals between earth and a satellite 22,300 miles up would have high signal attenuation requiring very high-power base transmitters and super-sensitive receiver equipment as well as highly sensitive satellite equipment to transmit and receive a clear signal. Signal/noise ratio would suffer from increased interference from interstellar and ionic plasmas.

The second type of orbit, in the lower altitudes within the range of 500 to 4,000 miles, reduces greatly most of the above-mentioned problems, but creates others. A satellite orbiting 500 miles up will circle the earth in one and three-quarters hours, and one 4,000 miles up, in four hours. Because of this high speed of orbit, time availability over any one place is limited. Further, complicated tracking equipment must be coupled with the transmitter and receiver systems of the ground stations to maintain contact with the satellite. Numerous satellites would be required in such an orbit to maintain continuous service.

Mr. Mathews writes that a compromise solution, put forward by Hilton and Dauncey in a paper to the International Astronautics Federation at Stockholm in August, 1960, would be to launch the communications satellite into an elliptical orbit, and at an angle of 63 degrees to the equatorial plane. This would satisfy most of the communications requirements, and also reduce the disadvantages of the synchronous and the low altitude orbit.

At latitude 63 degrees north the satellite would be 12,500 miles from the earth's surface; it would be 300 miles away in the Southern Hemisphere. This would provide communications by satellite for nine hours per day (a complete orbital time), and three such satellites in identical complementary orbits would give almost complete 24-hour coverage. Advantages are: the apogee remains fixed at 63 degrees latitude, eliminating complex tracking; and present rockets could launch the satellites into this orbit at its perigee point of 300 miles.

Mr. Mathews estimates that the cost of providing and maintaining a satellite system for television exchanges would be about $112 million to establish and about $56 million a year for maintenance and replacement, exclusive of research and development. This means that television would have to work with "x" international telephony interests to help absorb the costs. TV would use the "off-peak" telephony business hours, meaning receiving stations would have to have additional recording facilities (further increasing cost). It is suggested that for a television system to become a practical, economic proposition, a relatively low tariff must be set if the system is to compete with present-day methods.

The videotape recording which can be flown to any part of the world within hours, as Mr. Mathews sees it, is the greatest economical opposition to television relays via satellite at this time.

SPACE COMMUNICATIONS AND TELEPHONY

In the economics of space communications as applied to telephony, some experts[9] have predicted that space satellites will be used for routes greater than 1,000 miles long; lesser distances will be supplied by surface cable, surface radio link, or submarine cable. Areas to be covered will depend upon commercial need, and this will be decided upon by projecting future traffic as well as current business. For instance, there are fifty separate telephone networks in Africa, and these are mostly connected to Europe via poor circuits, if at all. The African continent is expanding and since the European international telephone link to Africa cannot readily be improved by conventional means, it follows that space communication is very important in this area. It would be expected that commercial interests would invest money for a suitable space communications system.

The largest international telephony commercial need is between continents which have seaboards on the Atlantic—from the United Kingdom, America, Europe, to the Middle East. Also, from the United Kingdom and Europe to the Far East, and North America to the Far East. On these routes satellites may have to be used two or three times over to effect connection; development may therefore be slower due to higher operating costs.

Transmission delay also becomes a problem. During the moon bounce tests, it took five seconds for a question and answer between California and New Jersey. Supposing instant vocal reaction to a question, it took 2.5 seconds for the question to travel across country via a moon bounce and 2.5 seconds for the reply to return. Single-sideband modulation was found to give superior voice quality over frequency modulation when using the moon as a passive reflector. It was equal to the quality of transoceanic radio telephony using short wave and ionospheric reflection. FM was almost unintelligible.

However, for the purposes of TV, the communications circuit gain must be increased by at least 30 db over that used in Echo I (124 dbm) before transoceanic TV is possible. Also, the balloon should be at least 2,000 miles up (the range of Echo I was from 1,000 to 3,000 miles maximum) increasing the circuit gain to 42 db. A 1,000-foot balloon instead of the 100-foot Echo I balloon should be used, and by transmitting at 100 kw and if the transmit/receive-antenna gain could be increased 12 db, or 6 db per antenna, then standard TV could be broadcast using passive satellites.[10]

However, the requirements for telephony are not so stringent. It has been proposed for commercial telephony purposes that two major terminal stations be established, the larger to serve primarily the maritime nations of Europe, and the second to serve the U.S. Under this system, more than two-thirds of the world's voice space communications needs could be served by a single, synchronous satellite in stationary orbit over the North Atlantic.

Accurate tracking of a nonsynchronous (orbit above earth between 500 and 4,000 miles) satellite is more complex than the communications system itself. The technical problems in Echo I concern aiming the narrow (0.4 to 1 deg.) antenna beams directly at the target, to within 0.1 of a beamwidth (0.04 to 0.1 deg). The tracking system used is a CW doppler-radar capable of measuring two angles and range rate. The west-to-east frequency was 2390 mc because this frequency was approved by the FCC and was termed the "correct" frequency band for future satellite and deep-space communications experiments. This falls within the 2000 to 4000 mc ideal band proposed by Mathews. Signal-to-noise ratio has been taken as the sole criterion of practical frequency selection by George W. Haydon[11] who has defined it as from 10 to 10,000 mc.

The Bell System[12] considers intercontinental television necessary enough as a business venture that they are going to launch experimental satellites under contract to and in

cooperation with NASA in 1962. Their reasons for this vary from the lack of a decision from the Government on satellite ownership, their contract with NASA, to basic business forecasts. A.T. & T. sees common markets "extending everywhere," international news events often more important than local, and the traveling American who expects to see the rest of the world at work and play as good business reasons for this venture. To date, however, the satellite array planned by A.T. & T. will be keyed to telephony service rather than intercontinental television. In this respect, A.T. & T. feels it must give high-quality telephone service via satellites or the rapid growth of traffic predicted for the future will not occur. In this regard they have planned a system based on many satellites in low-level orbits (nonsynchronous); specifically 30 satellites initially in about 6,000-mile polar orbits. Ground stations would have several steerable antennas to change from one satellite to another without interrupting communications. This system will allow increasing the number of satellites without increasing the frequency assignments; also, the active satellites will have repeaters handling four broad-band two-way radio channels. Each channel will carry 600 telephone signals or one broadcast quality television signal. This means that four television channels are possible for each satellite.

A.T. & T. plans now call for 12 broad-band two-way channels between the U.S. and Europe by 1980 using 50 satellites in orbit to insure that four satellites would be visible at all times to both continents. The tests in 1962 will include Telestar I, operating in the top 100 megacycles of both the 4,000 and 6,000 mc common carrier bands[13] in an elliptical orbit (600 to 3,000 miles high). Ground-to-satellite transmission will be in the 6,000 mc band while satellite-to-ground transmission will be in the 4,000 mc band. Wide swing FM will be used to transmit a baseband signal of 2 mc. Tests will include transmission of one-way television and multiplexed telephone signals; also the transmitting of two carriers through the single repeater to provide two-way telephony. For an operational satellite it is expected that two 50 mc repeaters (one for each direction of transmission) would be required to provide capacity for 600 two-way telephone conversations or one two-way television signal.

American Telephone & Telegraph Co. has been picked by NASA to provide "systems engineering support" for the nation's effort to land a man on the moon. This should be of interest in light of A.T. & T.'s part of an interested common carrier in a communications satellite system, since the technology and experience gained from the NASA contract will obviously aid the company in its satellite communications work.

Despite A.T. & T.'s intense interest in a communications satellite system, the company is investing $46 million to lay a transpacific telephone cable to be put into service in the summer of 1964. Total cost of the project is $84 million, and the cable will stretch some 6,300 miles between Hawaii and Japan, routed through the islands of Midway, Wake, and Guam. It will carry 128 two-way voice channels.

A. T. & T. estimates a new Atlantic cable would cost $75 to $175 per channel mile, while a 24-hour satellite link would cost $27 to $56 per channel mile with higher quality. A partial reason is that cable bandwidth is 0.14 mc and the predicted satellite bandwidth will be 40-100 mc (meaning more channels would be available).

From the foregoing facts, and opinions of authorities in the satellite communications field, it appears very likely that the first medium for intercontinental television will be a system of satellites, transmitters, and specialized receivers for established networks serving only those areas having specialized receivers which can retransmit the signal on frequencies that can be received locally.

The first step will be to launch and use the satellite system for telephony purposes. The use of the satellite system for television will be gradual, and will most probably wait until the telephony use has been fully developed. There will be keen competition from recorded videotapes, and from improved worldwide air delivery service, that will tend to delay satellite television service until the economics of the medium have been reconciled, and high-quality transmission stability has been achieved.

FREQUENCY BANDS FOR SPACE COMMUNICATIONS

In 1959 the ITU Administrative Radio Conference in Geneva, Switzerland, received specific United States proposals providing for the functional communications aspect of satellite operations such as tracking, telemetry, guidance, and command, but no provision was made for the relay of communications traffic in the radio frequency requirements for space and earth-space-earth communications. The 1959 Radio Regulations provided spectrum allocations only for experimental space studies. In 1963 the problem of allocations for operational space communication will be considered.

Specifically, space communication will include:

1. Telegraph relay
2. Graphic relay
3. Telephony relay
4. Data relay
5. Television relay
6. AM/FM broadcast
7. TV broadcast

The operational frequency will most probably be limited to the spectrum between 1,000 and 10,000 mc. Interference for space communications below and above these limits is the controlling factor. Ideal limits for satellite communications systems are 2,000 and 6,000 mc. Frequencies within the ideal band are open to interference from and to other services which already use frequencies within this part of the spectrum. Geographical isolation of transmitters and receivers would enable sharing of frequencies but this must be well planned, as interference can extend to 38 miles at frequencies of 200 mc and 55 miles at 6,500 mc.

The FCC has been requested to combat this problem by rescinding present allocations and, in reallocating, reserve the frequency band 1,000 to 10,000 mc for space communications. Since communications via satellites have international applications, the United States will have to appear before the 1963 International Conference to consider allocation of frequencies for space communication and other purposes with a workable plan that all interested nations can agree upon.

The International Telecommunications Union is optimistic of agreement,[14] since the many participating nations will be concerned for fear the large countries, such as the United States and Russia, might use the lower microwave frequencies in a way that may cause significant interference to their own ground services.

The FCC has recommended the frequency band between 3,700 and 8,400 mc for voice satellite communications, and it appears this will be the U.S. position before the ITU conference in 1963. No frequencies have been suggested to date for educational purposes in the satellite system--either radio or television. (This is discussed further in another part of this report.)

A review of available literature limits practical space communications via satellites at the present time to the 1,000-10,000 mc band. It is expected that by 1970 the 10,000 to 15,000 band could become practical. This expectation is based upon potential improvements in transmitting and receiving equipment.

The opinions of most commercial developers of communication satellite facilities on frequency requirements are generally those of Lockheed.

Lockheed[15] finds space frequencies best between 1,000 and 12,000 mc. Because of rapid rise in galactic noise below 1,000 mc, lower frequencies are not suited for space communications. Frequencies at and above 12,000 mc are subject to atmospheric attenuation which rises rapidly with increasing frequency. However, Lockheed feels that these higher frequencies, particularly those above 20,000 mc, are useful for space-space communications and functions.

In assigning frequencies in which various media would operate, Lockheed warns that there is more to satellite communications than just the point-to-point communication via the satellite relay or repeater station. Other frequencies are needed for:

1. Telemetry for vehicle flight tests
2. Telemetry for vehicle operations
3. Vehicle Tracking
4. Vehicle guidance
5. Vehicle command and control
6. Transmission of payload data
7. In the case of commercial space satellite communications, point-to-point communication by means of satellite relay or repeater station.

There would be twenty discrete frequency assignments required for a commercial communication satellite system. Many of the functions noted above (from 1 through 6) can be made on a relatively narrow-band basis interspersed with other functions throughout the usable portion of the spectrum. The use of frequencies for the collateral functions would be based upon time-shared and geographically shared use with other services.

The question of spectrum sharing in order to get the most use out of available frequencies depends upon two major conditions:

1. The necessary distance required between ground stations for the various communications systems (65 to 100 miles).

2. The requirement that passive or active satellites in one system not be illuminated by ground antennas of another system operating on the same frequency. (To avoid interference a satellite must lie 3 to 5 degrees off the main antenna beam even when highly directive ground antennas are used.)

In the case of synchronous satellites, this sort of interference is reduced, since all ground antennas would be directed toward a fixed point, as over the equator.

Sending and receiving stations for space satellite communications will have to have some degree of geographic isolation both to avoid interference from other types of communication propagation, and to avoid interfering with them. In the case of passive satellites, site selection become more of a problem because of the high transmitter power required,

and the susceptibility of the receiver to interference sources. Low altitude systems will be more difficult to site than synchronous systems due to the low main-lobe elevation in low altitude systems.

Initially, commercial space communications will require only a few sites near the U.S. coasts; later more will be required. Military installations and others now provide sites for radio astronomy, tracking, telemetry, guidance, command, and control throughout the United States.

PROPOSED OWNERSHIP OF
A U.S. COMMUNICATIONS SATELLITE SYSTEM

There are three proposals before Congress concerning ownership of the projected U.S. communications satellite system. One, submitted by the President, calls for a private corporation owned by communications companies, other firms, and the general public, which could buy stock. This corporation would be under tight Government regulation.

Another proposal, sponsored by Sen. Kerr, also calls for a private corporation, but with ownership limited to communications companies, such as the American Telephone and Telegraph Company.

A third proposal endorsed by Rep. Ryan and Sen. Kefauver calls for sole Government ownership.

Mr. Minow, FCC Chairman, backs the Kerr plan, along with A. T. & T., and other common carriers.

As pointed out earlier, the President has appointed Dr. Irvin Stewart as director of telecommunications planning to advise the President on the space system as well as on other telecommunications matters.

The proximity in time to global voice and television coverage appears to be limited only by when the Administration will act on the voice communications satellite system. The system will occur in this decade[16], and some authorities are not so interested in just how this will occur, but in when, what types of hardware, what form of control, and what character of international traffic. Sarnoff, of RCA, considers communications satellites as distance boosters, and from this he feels that transoceanic space communications will not make anyone rich overnight; rather the question of satellite ownership should guarantee direct access to these satellites by all present and future organizations licensed by the U.S. Government to operate in the field of international communications. Sarnoff says the system should be designed so that every licensed American organization can establish, own, and operate its ground stations for transmitting and receiving signals via the satellites.

RCA has proposed a space communication system using large capacity, synchronous satellites positioned at two or three locations about 22,000 miles above the equator. RCA favors a joint government-industry group to speed up and concentrate efforts on research and development in order to agree on the best satellite communications system and put it into being. Sarnoff is also interested in giving the United Nations programing access to the first satellite television channel, which is a move toward global political education not far removed in its purely educational aspects from worldwide televised education. He further suggests that for the developing and neutral nations the global televising of United Nations at work is a good way to communicate its aims; it follows that if this thinking is accepted the concepts of worldwide TV education are closely analogous.

A nonprofit corporation for satellite communications made up of international common carrier companies should be established immediately according to an article by staff writers

in Signal, December, 1961.[17] This corporation would establish an operational active communications satellite system by 1965 using medium or high altitude satellites, or a combination of both. These are also the main recommendations of the Ad Hoc Carrier Committee report to the FCC, October, 1961. This committee was made up of twelve international common carrier organizations.

Such a corporation would have to be organized so that no one company could "dominate or control the development, construction, management, operation or use" of the satellite system. The FCC would establish rates. The Ad Hoc Committee warned, however, that a target date of 1965 for operational use could not be met unless such an organization is established promptly, and international agreements on frequency allocations and other matters are completed immediately.

Andrew G. Haley, writing in the November and December, 1961, issues of Signal,[18] discusses the value of space telecommunications as related to exploring outer space. The question of frequency allocation and international agreement on such allocations centers around potential radio control interference which could destroy a space venture. Without positive international regulation almost all space activities will be conducted in an atmosphere of calculated risk subject to the transmission of an interference signal from an "inept co-user" of radio spectrum. To date the Iron Curtain Countries have refused to enter into any binding agreement on frequency allocations and it is most doubtful that they ever will.

Further, to date the lack of clarification of the responsibilities of the FCC and NASA over satellite communications in the United States has delayed work that private enterprise contemplates and feels can be done. Hughes Aircraft Co. is prepared to launch a satellite to handle "1,000 or more" voice channels upon receipt of a contract and clarification of the Government's role in space communications. There is some feeling that the administration might take away space communications planning from the FCC and delegate it to NASA. Some members of Congress have threatened to hold a Congressional investigation should this occur; this would only mean further delay which would benefit other nations, notably Russia, who presumably are going ahead with their own space communications planning. Congress to date is seen as probably favoring the Kerr private enterprise approach with FCC rate regulation, and with NASA carrying out its present functions—that is, NASA would provide the launching facilities for the communications system and the FCC would regulate its operations through its rate-making powers.

THE CASE FOR EDUCATION

In relating the technical problems, and service opportunities in satellite communications to the needs and responsibilities of education, some two hundred outstanding educators and educational administrators at school, college, and university levels throughout the country were consulted.

It was generally conceded that it was difficult, if not impossible, to relate directly the opportunities in space communication to the immediate needs of education in the United States. There was no lack of agreement on the fact that the needs of education are increasing daily, and that there is an equal increase in the relationship of American education to that existing in the world generally.

The following ideas were discussed at all the advisory conferences:

1. Is it feasible for education to use such a medium as a space satellite for transcontinental or intercontinental communications?

2. For what purposes could such a facility be used? Would it have a value for tying together institutions of higher learning, or would it be more practical to look forward to general direct broadcasts? Or would the sharing of important and significant teaching resources be the major emphasis of such a system?

3. Should specific frequencies be reserved for education? If so, how many? And in what areas of the spectrum?

4. What is the best domestic agency to control space communications as far as education is concerned? What should be the relationship of the educational community in the United States in international exchange of educational data?

5. What kind of representation should education have in the conferences and negotiations for allocations of frequencies and for assignment of facilities?

6. Is it possible that reservations or allocations made now might set the pattern for the next several generations or will advancing technology, such as the multiple use of single frequency techniques and optical masers or lasers, make present frequency assignments obsolete?

7. Will there be a demand that government assume responsibility for providing education with such facilities, in light of the enormous sums of money the government has spent on developing such facilities?

These were not specific questions but merely general ideas which were discussed with a great deal of latitude in each of the conferences relating to this survey.

One of the best basic discussions of the problem of using satellite communications for

transcontinental or intercontinental transmission of televised education was contained in the Brookings Institution report prepared for the National Aeronautics and Space Agency in 1961.[19]

This report divided the problem into two parts. First the use of radio and television education via satellite in underdeveloped areas and the use of these same media in advanced countries.

Regarding the first, the Brookings report said: "The possibility of teaching in underdeveloped areas via satellite-based radio and television have been much commented on. Again, it is necessary to keep in mind that both the technical prerequisites for extensive satellite-based television capacity and the reception requirements make it clear that the opportunities to use television in underdeveloped areas on anything more than a demonstration basis are very probably some years distant. Auspices which did not require potential profit or national gain as prerequisite for a technological investment might be able to accelerate the development. In addition to satellite development costs, the cost of adequate local receivers, adequately distributed, would be involved. Requirements for reliability, maintenance, and replacement capabilities must also be met. . . .If accelerated development appears likely, research is urgent on teaching in nonliterate societies via radio and television. The motivation to learn is not inherent in the human in any sense important here; rather, it depends upon culturally given attitudes toward learning per se, toward what is worth learning, and toward the pace of change which is acceptable in traditional terms. Moreover, learning usually depends for its support on the source of the message, in particular on face-to-face experiences. This is especially true in underdeveloped or tradition-oriented societies. . . . When it is clear what societies or regions might benefit more from teaching introduced through television via satellite than from traditional or less costly forms, specific answers to the problems discussed above will have to be derived for the particular cultures involved. However, much preliminary fundamental research will be necessary to discover the general nature and dynamics of the relationship of radio and television to learning and culture change in underdeveloped societies."

In regard to the use of radio and television interchange between advanced countries via satellite communications, the Brookings report had this to say, among other things: "This suggests that satellite-based communications, with their extensive capacity, could have great educational utility. However, expected developments in film, video tape depository libraries, and airborne television might provide more efficient means of serving formal education sessions before satellite systems become a reality. Nevertheless, active repeater satellites could make possible "live" regional presentation of lectures and special events, which now must be taped and distributed singly to schools and local transmitters; such problems as schedules for viewing time and accommodating time differences must be solved and comparative costs studied. A further very probable utility of the new system could be its transmission (perhaps during low-traffic periods) of television taped material from central depository libraries to schools. The expense of television material might thus be kept low—since the tapes could be erased and retranscribed—and schools would have access to a much greater body of materials than they otherwise might be able to afford. Research activities have been going forward for some time on the impact of telecommunications in education and will undoubtedly continue. Since a major premise justifying the development of satellite communications is the enhancement of such impacts and especially for educational purposes, research in this area should be supported and encouraged."

The Brookings report further indicated that other educational uses might be found for space satellite communications—such as scientific and educational conferences, medical conferences, etc. This idea was expressed by several deans and college presidents taking part in the various conferences. There is undoubtedly much to be said for the international and intercontinental extension of the conference technique which ordinarily could not be accomplished by means of physical transportation.

In his address to the first session of the 87th Congress on the subject of satellites and the use of satellites for education, Sen. Warren Magnuson said, among other things, "Everywhere in the world, people, regardless of the stage of their advancement, will welcome visual instruction on how to decrease mortality, particularly infant mortality, by the adoption of simple health measures. They will welcome programs on how to increase their food production. They will welcome early warnings of violent storms or floods. They will welcome on-the-minute news telecasts of events and the personages shaping them in other parts of the world. They will welcome information on markets and sources of supply. The communications satellite in my opinion can be the most valuable instrument in goodwill and understanding in the history of the world. . . .Perhaps we may see the day when there will be a special radio and television communications network for use by the health-science profession. Such a network would interconnect medical schools and research centers and reduce informational obsolescence by the rapid dissemination of new developments. It would also offer scientists and practitioners a mechanism for nationwide information storage and retrieval, by referring to a centralized documentation center. With the advent of communication satellites, a worldwide biomedical communications system is not only possible—but may ultimately be a necessity."

Present development in space satellite communication, and its potential for use in long-distance transmission of educational television discussed in the various conferences resulted in some definite opinions which seemed to be fairly representative.

In the question as to whether or not satellite communication is feasible for educational television, there was a positive answer from 90 per cent of the persons participating in the various discussions. On the other hand 10 per cent felt that the rapid development of vast transportation facilities and the use of videotape would preclude any large necessity for being concerned with the use of space satellites to transmit educational material over long distances.

As an example of this feeling, Rudy Bretz, head of educational television at the University of California in Los Angeles, had this to say: "Supersonic planes will be traveling in excess of 2,000 miles per hour. The 2,000-mile-an-hour plane can reach anywhere in six hours, probably most places we would care about in three or four hours; and then there is the rocket mail. I can't guess at the economics of this, but I would guess that the speed of delivery of a ballistic capsule carrying videotape would be only slightly less than that of a broadcast signal: I would guess probably less than forty-five minutes anywhere to anywhere. When this is planned to begin, I don't know, but with the present speed of development I would not be surprised to see it within a few years."

As a reverse to this position, Dan Cooper, head of the education department at Purdue University, said, "The advantage of satellite transmission of educational programs over air transport of tapes, or over direct export of teachers seems to be in the merit of the completeness of the coverage gained in one grand move; and the practicability of the manpower requirements involved. Certainly we do not have the requisite people for direct export. Nor would many of the people abandon their present homes for primitive conditions if they were available. Even a system of air transport of tapes would require innumerable man hours of time and unending negotiations, area by area, throughout the world. The situation seems like a city served by many private wells, versus a public water supply into which all may tap; or like the many private libraries in towns of colonial days compared to the present scheme for a public library which all may use."

There seems to be an overwhelming belief that the future does hold great prospects for long-distance use of educational television through satellite communication. However,

there seems to be less certainty as to the purposes for which such facilities ought to be used.

One group felt that in whatever development occurs, positive steps should be taken to avoid any possibility of governmental censorship of educational materials communicated by television via satellites. At least 10 per cent of the discussants felt that any development should be concerned with a two-way process of communications through television; that no nation should claim a priority or a monopoly on one-way communication, because such monopoly would limit the spread of education throughout the world.

Generally, it was agreed that there were more opportunities for educational development through this medium by using it for international conferences and symposia; for discussions between educators or groups of educators; and the sharing of clinical material. In the sharing of clinical material there was a fairly general agreement, and most of the comments in this direction supported Sen. Magnuson's thesis as previously stated. In this matter, Dean Meierhenry of the University of Nebraska had this to say: "I know, for example, that the people in our medical college are anxiously awaiting the day when it might be possible to transmit operating techniques from medical colleges and hospitals in Europe to the medical colleges in this country. . . .I am certain that professional schools would simply develop schedules that would permit them to take advantage of direct broadcast even if it came at hours that were undesirable. We are certainly moving into a period also when much more international intercommunication will take place, especially among educational institutions. In such practical areas as language instruction alone I can see its value. Even more so, however, would be the possibility of transmitting directly and instantaneously from unique laboratory settings in different parts of the world."

Only 10 per cent of the discussants felt that we could reasonably look forward to open broadcast for general reception in the foreseeable future. However, as many as 50 per cent agreed that this would be an ideal to look forward to, and that it was probable that the time would come when such a technique could be used, in spite of language barriers and apparent limiting cost problems.

Ninety-five per cent of the members of all groups felt that education should be officially and equally represented in all negotiations and conferences relative to the distribution of the space facilities and the allocation of frequencies to be used in conjunction with them. Eighty-five per cent indicated that the educational representatives at all conferences should insist upon the reservation of specific frequencies and specific shares of space facilities for education. On the other hand 15 per cent felt that education would have a better opportunity if its representatives insisted upon a legal requirement for all commercial operators of such facilities to provide specific times for the international transmission of educational material.

On the question which has been raised of the use of commercial facilities in off-peak periods of commercial transmission for the transmission of educational television materials, many of the groups felt that there would be no such thing as "off-peak" periods because of the time differences in the world. They felt that any hour would be an "off-peak" period in some area and an "on-peak" period in other areas, which in effect would leave the educational alternative as no alternative at all.

Approximately 50 per cent of the conference groups felt that the Federal Communications Commission was the best agency to control and regulate the satellite communications facilities on a domestic basis. Twenty per cent of the discussants had no opinion on the matter of domestic control, but felt that whichever domestic agency was responsible for international negotiations, it should have some representation from education. Some 30 per cent of the conference groups felt that some agency other than the Federal Communications Commission ought to allocate frequencies and facilities for the satellite communications.

The National Education Association felt that:

"NASA and FCC should jointly share responsibilities for developments in this area, with a clear definition of the relationships and roles of each as to engineering, rate regulation, and public service responsibilities. The public interest demands some type of regulating control on the part of the government whether the operation is public or private."

One group felt that an agency of the State Department should be set up with representatives from education, from the Department of Commerce, and the Department of Defense, to assign facilities and regulate the use of frequencies and negotiate with the international agencies as to the necessary regulations. There was another group who felt that the NASA was the most logical agency to control and regulate satellite facilities, but that in order to do so with justice to educational services, a special division ought to be set up in NASA for this purpose. It was also suggested that an independent agency, as part of an over-all international agency, constituted domestically as a sort of super Inter-departmental Radio Advisory Committee ought to be established to work in conjunction with the Federal Communications Commission on a domestic basis.

These attitudes on the part of the various discussion groups relative to control of satellite facilities are presented merely to indicate the kind of thinking which seems to be extant in the educational community. One thing that seemed obvious in all of these discussions was that in the matter of control the educators were particularly concerned with the right of education to use whatever facilities are available to share knowledge around the world without fear of political censorship, and without dependency upon private commercial agencies.

There is no provision at present for any allocations for educational purpose; and in the present planning there seems to be no equitable manner in which educators can buy shares in or lease facilities from a commercial communications satellite system. The indications are that unless frequency allocations for educational television are made now, educational institutions will be unable to use satellites when the time comes that they can afford it. Considering a communication satellite as just a distance booster (which is in reality all it will be) and therefore in the realm of electronic engineering, the educators have little feel for the technical machinery that transmits their educational program; they only need the wideband frequency allocations to insure doing this when they are ready.

To date the recommendations of the Federal Communications Commission that the frequencies between 3,700 and 8,400 mc be allocated for space communications purposes have not been significantly questioned. However, since all the television frequencies are in the bands much lower than those recommended by the FCC, the contemplated U.S. position does not now appear to inhibit future allocations of TV spectrum space in satellite communications.

Nevertheless, rapid advancements in equipment design, economy of new, more efficient and more versatile transmitting-receiving equipment, indicate that educators should petition now for space satellite frequency allocations for educational use. The engineers think that the spectrum range from 1,000 to 10,000 mc should be considered for educational purposes since when television begins to use satellites as distance boosters, the equipment will be capable of handling TV signals throughout this range.

The frequency range from 1,000 to 10,000 mc is adaptable to direct reception as well as pickup and rebroadcast via existing land networks. Historically, techniques for direct broadcast reception have moved to higher and higher frequencies, and it is not beyond the realm of feasibility to conceive home broadcast receivers utilizing frequencies in the 2,000

mc range and ultimately capable of pickup of direct satellite propagation. The criterion of use will be the technical improvements in equipment and the economic advantages.

The two major methods of transmitting educational material via communication satellite that seem the most probable are: real-time transmission by distance-booster satellite to be picked up and broadcast by land-based television stations or networks, and off-peak or non-prime-time transmissions to be picked up and recorded for later rebroadcast.

Both of these methods demand the existence of transmitting and receiving stations, plus local networks for conversion of signals and/or rebroadcast from tapes. A likely solution to the problem of equipment expense would be to lease services from or have an equity in the commercial system that will be transmitting telephony signals and other data. This commercial carrier probably will either be an "open end" common carriers' carrier or a private corporation chartered by the U.S. Government. The appearance of a Soviet system with equal capabilities must not be overlooked.

In order to lease or purchase facilities to broadcast, certain frequencies and channel allocations must be set aside for educational broadcasting via space satellites.

If this occurs, then programs can be broadcast once for all interested receivers, eliminating the need for making "x" number of tapes for distribution. Language barriers could be overcome if there were native translators at local receiving sites to "dub in" the audio. Educational institutions on a global scale could tape broadcasts and build up an educational TV library at far less expense than they could obtain this information today.

Real-time broadcast of exceptional lectures by leaders in various fields of education could offer students around the world an "on-the-spot" classroom attendance which they could never have otherwise. If the lecture merited global and immediate interest, geographic time differences would not be of great importance, since educational institutions would accommodate their hours to the schedule.

The commercial use of communications satellites is recognized as part of the current battle throughout the world for the minds of men—as the impact of communications via space on underdeveloped peoples of the world will greatly influence the Western position versus that of Communism and/or Totalitarianism. Consequently, the problem of Communist jamming, interference, and planned troublemaking must be considered. In any global educational television undertaking, the interested agency will face the problems the United States Information Agency and the Voice of America face today from Communist interference.

"Worldwide" television in the initial years will in all probability operate through the distribution of program material for broadcasting from conventional television stations throughout the world and not from direct satellite-to-viewer transmission. For instance, a station in Liberia would tape a program from a satellite-transmitted signal, and rebroadcast it later after converting the program to local reception frequencies, or in some instances, where a network system exists, the receiving station would instantly translate the intercontinental broadcast material into local frequencies. Land-based receiving stations for communications satellites will serve as translator transmitters and as relay stations for delayed broadcasts.

It is very probable that no one method will dominate the educational service, but any method will face many technical, educational, and sociological problems. These should be given serious consideration in any planning for use of communication satellites for purposes of international education.

There will be many complex cultural and psychological factors to inhibit the smooth

functioning of any worldwide or intercontinental educational effort. Significant among these, of course, will be the multiple barrier of language differences.

Language for effective translation may require full knowledge of local lore, including vernacular and idiom. In visual presentation the same picture evokes varied images and responses among different audiences in different parts of the world; the subject is not divided up according to the same rhythmic patterns. Since tastes and conditioning are not identical, people do not see the same thing when looking at the same picture.

Program censorship and control is in many instances a sensitive question; a program might inadvertently contain objectionable material which would be deeply resented by viewers in a particular region or nation, or by governments.

Time zone differences, rate of literacy, and concentration of populations are other factors which will affect the success of international educational television.

Real-time transmission and rebroadcast via locally made tapes depends upon the solving of technical, economic, and standardization problems. To illustrate: A further problem associated with language barriers and time differences is the incompatibility of line and frame scanning standards. Any direct exchange between operating sites requires the adoption of standards conversion procedures. Present procedures introduce distortions not acceptable for good reception. The following table shows the main scanning standards now used throughout the world.

Country	Line Standard	Field Standard (fields/sec.)	Video Bandwidth (mc/s)
United Kingdom	405	50	3
Continental (except France, etc.)	625	50	5
France	819	50	12
U.S.A./Canada	525	60	4.2
C.C.I.R. recommendation	625	50	6

A further question is whether the educational television program as envisioned in the United States is to be a two-way system or just a one-way system. (See suggestions of the Brookings Institution report to NASA.) If it is to be a one-way system there is a need for only one transmitter and "x" number of appropriate receivers. However, a two-way system would use multiple transmitters and receivers as the needs arise.

A one-way educational television communications system would create embarrassing questions as to why the United States (or, for that matter, any other country such as Russia) had assumed full authority in the selection of subject matter. A two-way system must consider the possibility of a Communist-controlled space satellite communications system that might force the Western educators to accept limiting and unpalatable international controls. It is conceded that it is very possible that a communication satellite system developed by the United States will be matched by a Soviet system. This would in turn bring pressures to internationalize radio and television broadcasting and establish international controls that would in a large measure depend upon the balance of military and economic power.

It seems clear that there are disadvantages as well as advantages to the development

of a communication satellite system for education, but the imperatives to the use of such a system when it is available makes it urgent for American education to give increasing consideration to the ways and means of such use.

The National Education Association, through its deputy executive director, Lyle W. Ashby, made this statement:

"Regardless of the specific system of satellites, transmitters and receivers eventually established for intercontinental television, and regardless of the basis of operation finally agreed upon, whether public or private, one paramount consideration should be recognized from the outset. The satellite communication system should be used for purposes of global education as well as for entertainment or industrial purposes. It is imperative that intercontinental television be used to inform, to enlighten and to make a contribution to human understanding between the peoples of the world. The new communications satellite system would seem to offer countless educational possibilities; for example, it could make possible a full-scale attack on illiteracy on a global basis; it could telecast sessions of the United Nations; it could serve as a means for the exchange of research information, as well as the sharing of world-wide scientific and cultural experiences; it could serve to transmit data between educational institutions.

"Consistently, through the years, the Association has endorsed and actively supported the general principle that education is entitled to a proportionate share of spectrum space and that a balanced programming service to the American public demands that consideration be given to both educational and non-educational uses of the medium. We are confronted now with a similar situation, but this time on an international level, wherein we have at our disposal a natural resource to be utilized for the benefit of society as a whole.

"The Association feels it highly important that educators be invited from the very beginning to be a part of planning for the educational use of the satellite system. Conceivably, there might be established an interim group to represent education in this matter, similar to the present Joint Council on Educational Broadcasting of which NEA is a constituent member, in order that all facets of the educational profession will be represented. In any event, the NEA, representing 800,000 American teachers, is anxious to participate and otherwise assist in necessary conferences to recommend policies in this area. We feel it essential that organized education be represented at all such conferences on the subject, both national and international."

For the most part the various discussion groups analyzed the potentials of educational television via satellite and arrived at some general agreements. Most of the attitudes reflected in this report are derived from those general and sometimes tentative agreements. However, there were some of the discussion members who took time out to write some rather specific suggestions. Some of these are so eloquent in the case for education that they are presented here. Dr. D. H. Cooper, head of the department of education at Purdue University, wrote as follows:

"Whatever will expand and expedite (not to mention dramatize) world-wide communication should of course be used for educational purposes. Everything we know about international relations, everything we believe about humanitarian ideals, everything we are learning about winning the great world struggle of our times, should impel us to seize for world-wide educational purposes any device which aids communication. In case this thesis needs reinforcement, let Theodore W. Schultz, holder of the Charles L. Hutchinson Distinguished Service Chair of Economics at the University of Chicago, be heard:

U.S. foreign aid programs have'grossly neglected' areas of 'the really big pay-off.' The abundance of modern agriculture and industry is not to be had by a people who are predominantly illiterate and unskilled. . . .We have put most of our money in public health, agriculture, engineering, industrial productivity, public and business administration, and in some trade schools and vocational training. . . .Surely we and they have been very shortsighted in the neglect that this emphasis implies of elementary and secondary schools. . . .The really large pay-offs are likely to be in precisely the areas that have been so grossly neglected.[20]

"Or hear the English scientist and author, C. P. Snow:

The main issue is that the people in the industrialized countries are getting richer, and those in the non-industrialized countries are at best standing still. . . .Whatever also in the world we know survives to the year 2000, that won't. Once the trick of getting rich is known, as it now is, the world can't survive half rich and half poor.

The West has got to help in this transformation. . . .It is technically possible to carry out the scientific revolution in India, Africa, South-east Asia, Latin America, the Middle East, within fifty years. . . .This is the one way out through the. . .menaces which stand in our way. The scientific revolution on the world scale needs, first and foremost, capital. . . .The second requirement, after capital, as important as capital, is men. . .the third essential of the scientific revolution. . .is an educational programme as complete as the Chinese, who appear in ten years to have transformed their universities and built so many new ones that they are now nearly independent of scientists and engineers from outside. Ten years. With scientific teachers from this country and the U.S., and what is also necessary, with teachers of English, other poor countries could do the same in twenty. That is the size of the problem.[21]

"So much for the need to use, for educational purposes, any and every facility which will expand and hasten communication."

Dr. L. D. Haskew, Vice-Chancellor of the University of Texas, made a particularly strong statement: "Gazing into the future, I think it very likely that the use of satellites for educational communications is possible and that perhaps it should come to pass. The first practical question is the one of defraying the costs. As usual, I suppose education will have to 'borrow' facilities and personnel originally authorized for other purposes, and this, of course, puts education in the usual beggar position. The technical people with whom I have talked think that eventually our present conceptions about frequencies will become obsolete. However, all choose a long distant date in the future. For the present, I suspect that everyone should proceed as if current frequency allocations are all that are going to be available and fight for those allocations. Therefore, I think it is highly important that education should demand and receive adequate representation at all international negotiations regarding the use of satellites in communication."

All evidence indicates that it is almost impossible at this time to project the specific uses of satellite communications for educational television, but there is an awareness among all the educators who have given thought to these potentials of the demands of the future and of the responsibilities which American education will have to assume for the entire world.

In the light of the rapid developments in the technology of communication, and the increasing demands for the sharing of all knowledge by that large underprivileged portion of the world, all of the advantages of communication technology must be used in some measure for the expansion of education.

SUMMARY AND RECOMMENDATIONS

From the data available, it seems obvious that the United States will have one or more operational communication satellite systems in the next ten to fifteen years, and that the use of these systems will be shared by various other nations through international agreements, and will be used for various purposes.

The data also indicate that the policies and regulations established during the period of development in the years immediately ahead will set and govern the use of the communication satellites for a long period of time. These policies are being formulated by the Inter-departmental Radio Advisory Committee of the United States Government, in conjunction with the Director of Telecommunications Management, and the Federal Communications Commission. The only modification of the policies worked out by this group will be in the compromises which will be made as a prerequisite to international agreement. It is significant that the use of communication satellites must of necessity be an effort in international cooperation, and while the technological lead of the United States in this field may give it a predominant position in international negotiations, it is obvious that the use of such satellite systems cannot be unilateral or dominated by one nation.

It seems that the control of the various international agencies involved in the operation of satellite communications will differ from country to country. The proposals for the control of such operating agencies here in the United States has been discussed at some length in this report.

It is significant that in the present planning for policies affecting communication satellites, and the assignment of radio frequencies to be used in conjunction with them, no consideration has been given to education as an individual service. In the proposals for the operational control agencies there has been no provision for education. In these proposals there is no equitable manner in which educators can buy shares in or lease facilities from a commercial communication satellite system.

It seems obvious that if the projected needs of education, both nationally and internationally, are to be provided for, plans must be made from the very beginning to allow education to have a voice in the determination of the use processes of the satellite communication systems. It will also be necessary to allocate specific frequencies at the outset of international agreements for the use of educational television.

It is true that the use of space satellites for educational television purposes is not an immediate problem, and the process should be evaluated in terms of the next ten to twenty years. However, the consensus of all the conferences relative to this matter was that the satellite communication system, when developed, should be used for global education as well as for commercial and governmental purposes. There was general agreement that the cause of education is at least equal to that of commerce, industry, and government, and should be given equal consideration in a system predominantly developed and financed by the United States Government.

The manner in which educational use of satellite communication systems by educational institutions could be financed is not clear at the present time. It is also recognized that, while there are many possible uses for such a service it is difficult at the present time

to indicate specific areas of educational use of satellite facilities. However, the consensus is that such uses are inherent in the developing needs for education all over the world and the expanding responsibilities of the United States to help meet those needs.

It is also not clear at the moment as to what precise frequencies ought to be reserved for educational purposes, or in what number such frequencies ought to be set aside. However, in the present United States proposal of 3000 megacycles for the various areas of projected use, it seems unlikely that there will be enough frequencies to meet the commercial, governmental, and experimental demands, and at the same time provide an adequate number of reserved channels for educational purposes.

It seems obvious that in the light of the variables existing, and the unknown factors of financial resources and utilization requirements, the only way that education can be protected in the development of these facilities is to have educational representation in all planning groups and in all agencies of international negotiation.

It is recommended that the Department of Health, Education and Welfare have a representative on the Inter-departmental Radio Advisory Committee; and have such representative permanently established to participate in all planning and recommendations for the use of satellite communications facilities and such collateral matters as may be involved from time to time.

It is also recommended that the representative of the HEW on the IRAC establish a working relationship with the Federal Communications Commission and the Director of Telecommunications Management of the Office of Emergency Planning. The HEW representative should also seek membership in the United States Study Group of the CCIR of the International Telecommunication Union.

It is further recommended that the Department of Health, Education and Welfare, through its appropriate agency, proceed to form an Advisory Council to advise with its representative on the IRAC and the CCIR Study Group. This Advisory Council should be permanent in nature, and representative of the various areas of education in the United States. It is recommended that the National institutional and professional associations of educators and educational technologists be represented on this Advisory Council.

This committee would be responsible for meeting at regular periods with the HEW representative to consider problems concerning the sharing of communication satellite facilities, the allocation of bands of frequencies for educational radio and television purposes, and for recommendations to the President for the regulation, operation, and financing of such educational facilities.

It seems clear that only by the active leadership of the Department of Health, Education and Welfare, backed by the concerted planning and support of the educational community of the entire country, in some form approximating that which is here recommended, can the future interests and needs of American and international education be secured, and the development of space satellite communication serve one of its most important purposes.

Educators must have a voice in the planning, and in the distribution of the available frequencies. It is inconceivable that ten years of development could occur in the field of communication satellites, paid for mainly by public funds, and then so planned that all available frequencies or frequency bands would be allocated to all services except education.

FOOTNOTES

[1]"Satellites as Communication Relays," Space Handbook: Astronautics and its Applications, Staff Report of the Select Committee on Astronautics and Space Exploration, prepared from a study by the Rand Corporation, U.S. Government Printing Office, 1959, No. 37162.

[2]Comments of Lockheed Aircraft Corporation in response to FCC Docket No. 13522, March 1, 1961. Before the FCC In the Matter of Allocation of Frequency Bands for Space Communication.

[3]Comments of General Electric Company in response to FCC Docket No. 13522, March 1, 1961.

[4]"Communication Satellites Held Cheaper Per Channel Than Sub Cables," Electronic News, November 20, 1961, p. 20.

[5]Ibid.

[6]J. H. Felker (assistant chief engineer, A.T.&T. Co., New York City), "Satellite Relays and Broadcasting," Broadcast Engineering, October, 1961.

[7]"Satellite Development Keys Aerospace Talks," Electronic News, October 30, 1961, p. 56.

[8]L. F. Mathews, "Television Communications Using Earth Satellite Vehicles," The Journal of the British Institution of Radio Engineers, October, 1961, p. 349.

[9]J. R. Brinkley, "The Economics of Space Communications," URSI Symposium on Space Communications Research, September, 1961.

[10]Mathews, loc. cit.

[11]G. W. Haydon, "Operation Frequency for Outer Space Communication," Journal of Research of National Bureau of Standards, Vol. 64D, No. 2, (March-April, 1960).

[12]Felker, loc. cit.

[13]H. E. Weppler (radio engineer, A.T.&T. Co., New York City), "Big Era in Space Communications," Signal, November, 1961.

[14]Gerald C. Gross (secretary general, International Telephone-Communication Union), "The ITU and Space Communications," Signal, December, 1961.

[15]Comments of Lockheed Aircraft Corporation in response to FCC Docket No. 13522, March 1, 1961.

[16]Brig. Gen. David Sarnoff, USAR (Chairman of the Board, RCA), "Communications—A Look Ahead," Signal, November, 1961.

[17]"A Nonprofit Corporation for Satellite Communications," Signal, December, 1961.

[18]Andrew G. Haley (General Counsel, American Rocket Society), "Space Communications & Cooperation With Iron Curtain Countries," Signal, November and December, 1961.

[19]"Proposed Studies on the Implications of Peaceful Space Activities for Human Affairs," prepared for NASA by the Brookings Institution, March 24, 1961, Government Printing Office, No. 66831.

[20]University of Chicago Magazine, November, 1961, p. 10.

[21]The Two Cultures and the Scientific Revolution, Cambridge University Press, 1961, pp. 43-51.

BIBLIOGRAPHY

Aerospace. Issued by Merrill Lynch, Pierce, Fenner & Smith, Inc., 1961.

Coombs, William C., "Communication Theory Aspects of Television Bandwidth Conservation." Issued by U.S. Department of Commerce, National Bureau of Standards, Technical Notes, No. 25.

Curtis, Harold E., "Interference Between Satellite Communication Systems and Common Carrier Surface Systems." Bell Telephone Laboratories, Inc., Murray Hill, N.J.; Conference paper No. CP 62-343, November 1961.

"D. Radio Propagation." Journal of Research of the National Bureau of Standards, Volume 64D, No. 2 (March, April 1960).

Dudley, Edward J., "Electronics' New Semester." Electronic Age, Vol. 20, No. 4 (Autumn, 1961).

Feasibility and Role of State and Regional Networks in Educational Broadcasting, National Association of Educational Broadcasters, September 1959.

Federal Communications Commission. In the Matter of an Inquiry into the Allocation of Frequency Bands for Space Communications. Docket No. 13522. "First Notice of Inquiry." Adopted: May 18, 1960.

Federal Communications Commission. In the Matter of an Inquiry into the Allocation of Frequency Bands for Space Communications. Docket No. 13522. "Second Notice of Inquiry." Adopted: May 17, 1961. Released: May 19, 1961. Attachment: "Preliminary Views of the United States of America. Frequency Allocations for Space Radiocommunication."

"First Synchronous Satellite Goes Up in 62." Electronics, October 1961, p. 28.

General Electric Company. Comments submitted before the Federal Communications Commission, Docket No. 13522, "In the Matter of an Inquiry into the Allocation of Frequency Bands for Space Communications," March 1, 1961.

"Inter-Institutional Teaching by Television, in the Oregon State System of Higher Education." Report No. 1-1957-1959, March 1960.

IRE Transactions on Communications Systems. Issued by professional group on communications systems, September 1961. Vol. CS-9, No. 3.

Jansky & Bailey, "Report to the Ohio Interim Educational Television Study Commission on the Engineering Aspects of Establishing a State-wide Educational Television System for the State of Ohio." October 14, 1960.

Jansky & Bailey, "A Proposal for Determining Nationwide Television Channel Assignment Plans by Computer Methods." July 1961.

Jansky & Bailey, Inc., "Research on Advanced Data Transmission Techniques for Airborne Early Warning Communications." Contract No. AF 18 (600)-1654. Washington, D.C., August 14, 1959.

Journal of the British Institution of Radio Engineers, Vol. 22, No. 4 (October 1959); also Vol. 21 (January-June 1961).

Kappel, Frederick R., (Chairman of the Board, A.T.&T. Co.), "Growing Service to Meet Growing Needs." Communicating by Satellite. Issued by Bell Telephone System.

Kilbon, Kenyon, "Energy Conversion." Electronic Age, Winter 1961-62, p. 23.

Lockheed Aircraft Corporation. Comments submitted before the Federal Communications Commission, Docket No. 13522, "In the Matter of an Inquiry into the Allocation of Frequency Bands for Space Communications," March 1, 1961.

"Missiles and Rockets." Astrolog, September 1961.

"Needs of Education for Television Channel Allocations." Report by the National Association of Educational Broadcasters, in cooperation with Office of Education of the U.S. Department of Health, Education and Welfare, November 1961.

"Preliminary Views of the United States of America on Frequency Allocations for Space Radiocommunication." A report from FCC and IRAC, September 7, 1961.

"Proposed Studies on the Implications of Peaceful Space Activities for Human Affairs." Prepared for NASA by the Brookings Institution, 1961.

"Redstone Arsenal Closed Circuit Educational TV System." AIEE Transactions Paper, No. 60-59, 1960.

Sarnoff, Brig. Gen. David, "Communications—A Look Ahead." Signal, November 1961, p. 63.

"Satellite Astronomy." International Science and Technology Magazine, March 1962.

"Satellite Relays and Broadcasting." Broadcast Engineering, October 1961, p. 8.

Schafer, J. P., and Brandt, R. H., "Project Echo—960-megacycle, 10-kilowatt Transmitter." National Aeronautics and Space Administration Technical Note D-1129, October 1961.

"Seventh Summary of Research at Boulder Laboratories." U.S. Department of Commerce, National Bureau of Standards, Boulder Laboratories, for year ending June 30, 1961.

"Space Communication." Federal Communications Commission 27th Annual Report, Fiscal Year 1961, p. 114.

"Space Communications and Allocations of Radio Spectrum." Report of Hearings before the Communications Subcommittee of the Committee on Commerce, U.S. Senate, 87th Congress, 1st Session, 1961.

Space Programs Summary. Jet Propulsion Laboratory, California Institute of Technology, No. 37-21, Volume 1 (for the period September 1, 1961 to November 1, 1961).

Stelzried, C., Schuster, D., and Sato, T., "An Experimental 960 Mc Maser Amplifier System Applicable to Space Communications." Jet Propulsion Laboratory, California Institute of Technology, Technical Report No. 32-179, November 1961.

Stevens, Robertson, and Victor, Walter K., "The Goldstone Stations Communications and Tracking System for Project Echo." Jet Propulsion Laboratory, California Institute of Technology, Technical Report No. 32-59, December 1960.

Stuhlinger, Dr. Ernst, "Space Projects Present and Future." Signal, February 1962.

"Survey of the Administrative, Engineering and Programming Feasibility of a Six-State Educational Television Network." Survey in the Upper Midwest area prepared by the Twin City Area Educational Television Corporation for the National Association of Educational Broadcasters, March 1960.

Telesat—Telecommunication Satellite Business Planning Study, Part One. Lockheed Aircraft Corporation, Missiles and Space Division, January 1961.

Victor, Walter K., "Ground Equipment for Satellite Communication." Jet Propulsion Laboratory, California Institute of Technology, Technical Report No. 32-137, October 1961.

Webb, James E., "International Relations and Space." Signal, November 1961, p. 12.

Weppler, H. E., "Big Era in Space Communications." Signal, November 1961, p. 21.

APPENDIX

In February 1962, the European Broadcasting Union (E.B.U.) issued the following statement to its members:

TRANSATLANTIC COMMUNICATION SATELLITES AND TELEVISION

1. U.S. SATELLITE PROJECTS

The National Aeronautics and Space Administration (NASA) in America is working on projects to launch four experimental wideband relay communication satellites during 1962. The primary object of the experiments is with reference to telephone and telegraph communications: during the tests NASA also plans to transmit television picture signals.

The first two satellites are called "Telestar" and "Relay," the first being equipped by the A.T.& T. Co. and the second by RCA. Both organizations are equipping ground stations, the first to be at Andover, Maine, New England.

"Telestar" is expected to be placed in orbit in May 1962. About a month's notice of the date of the attempt is expected. If a launching does not succeed, at least 90 days would elapse before a new attempt could be made. The planned life for the satellites is one year.

The elliptical orbit of the satellites is expected to range between 5,000 to 900 miles from the earth and the orbital period to be about two-and-a-half hours. When the precise orbit of a satellite is known, a chart can be available showing the visibility periods. Television signals can be relayed only during the periods of mutual visibility from the U.S. and Europe: this could be 30 minutes maximum but for technical reasons may well be not more than 10 to 15 minutes.

It is unlikely that a complete "pass" of the satellite will be available for television purposes until some weeks after the first launching and possibly not before July.

2. RECEPTION IN AND TRANSMISSION FROM EUROPE

A transmitting and receiving station is being built by the U.K.G.P.O. at Goonhilly Down in Cornwall and will be completed by May 1962. A station is also being built at Lannion in Brittany which is expected to be completed by Autumn 1962. Stations in Italy and Germany are, it is understood, to be constructed in 1963.

In Great Britain all arrangements are the responsibility of the Post Office which will make the signals available to BBC, ITA and Eurovision organizations.

Circuits and equipment will be made available to provide a 525 line signal to RTF (for RTF conversion to 819 lines): and a 625 line signal to the rest of Europe.

EBU Working Party "L" has appointed a Sub-Group (BBC, RTF, ITCA, RAI and the Technical Center) to examine in detail circuit requirements to and from Europe.

3. PROGRAMME PLANS

The British G.P.O. has asked the U.S. State Department Telecommunications Division to state in whose hands will lie the control of arrangements for material transmitted from America.

Meanwhile unofficial information has been received from various reliable sources that the American Networks plan to collaborate in the first programme project and to bring in also the Canadian Broadcasting Corporation. It is supposed that NASA will be concerned with these plans and that USIA may also be involved. Clarification of the official position is awaited.

Some details are already available of possible American plans for the first exchange project.

The proposal is that the first live transmission should be from the U.S. to Europe, between 1600 and 1700 EST or 1300 and 1400 Pacific Time. This means between 2100 and 2200 CET. The first relay from Europe to the U.S. could follow on the next pass of the satellite about 2 1/2 hours later: but live broadcasts might be difficult to arrange at this timing of between 2330 and 0030 CET. The relay from Europe could alternatively take place on the day following the American transmission.

Plans for the American programme are being discussed in terms of quick pick-ups from Washington, New York, and Ottawa, with very short (30-second) greetings from President Kennedy, Secretary-General U. Thant, and Prime Minister Diefenbaker. These greetings might be followed by a quick switch to the Pacific Coast, possibly to the Seattle World's Fair; then pick-up from perhaps Denver or Salt Lake City, The Tennessee Valley, and perhaps New England. If there were time, there might be a pick-up also from French Canada.

Speech will be kept to a minimum in the first U.S. project. There will be one sound channel via the satellite; circuits for additional languages could go by cable.

On the European side, the Planning Group has been directed by the Programme Committee to formulate an EBU programme proposal for discussion at the meeting in April 1962 at Seville. First discussions will take place at the Planning Group meeting in London on 22nd and 23rd February.

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In the February 1962 issue of TV International Magazine, J. Stubbs Walker, Technical Editor wrote the following:

Britain is to become the key nation in what amounts to the nearest thing yet in world television. From the new L750,000 communications center being built by the GPO on Goonhilly Downs by the Lizard, Cornwall, the first satellite propagated television signals from America will be received and fed into the Eurovision network. All Europe, and possibly Russia, will take the programme.

Details of a major engineering operation in which the technical resources of the BBC, the independent television companies and the British Post Office are being pooled have been thrashed out at an international conference in London behind closed doors.

The meeting under the chairmanship of Mr. M. J. L. Pulling, assistant director engineering of the BBC, was of the technical committee of the European Broadcasting Union. Some forty top engineers, representing seventeen European countries, met at the Institution of Electrical Engineers.

The first of the communications satellites will be launched by the United States National Aeronautics and Space Administration in a few weeks. The firms responsible for the equipment at Goonhilly have been told that they are working to a "crash" programme; all the equipment must be installed and operating by the end of next month, or the middle of April at the latest.

Main contractors for the radio equipment are Standard Telephones and Cables, who have built the transmitter; Mullard, who are producing a special low-noise Maser receiver; Elliott-Automation whose electronic computer will be used to steer the 85-ft paraboloid aerial to track the sateilites; and H. C. Husband & Company, Ltd., designers of the aerial.

FRANCE UNREADY

That the Goonhilly equipment is completed on time has become of even more vital importance because the French postal administration, who were to have built a similar station on the Atlantic coast of France, now admit that their equipment cannot be ready in time. If they have all the luck, it will be operating in September, but it looks more likely that it will not be available until the early part of next year. The whole success of the experiment thus depends on Britain.

The importance attached to the satellite operation is indicated by the outstanding efforts that are to be put into the experiment by the EBU. One aspect given detailed consideration at the London conference is the time factor in putting the Eurovision network into operation when suitable television signals are received from America.

Mr. Pulling and Mr. L. F. Mathews, assistant technical controller of ATV, told me that the Eurovision network is generally organized weeks ahead of any international TV exchange, so that the set-up of cable and radio links can be programmed and allocated well in advance. There have been occasions when emergency links have gone into operation at a few hours notice, but these are rare, troublesome and uncertain.

For the satellite relays, however, Eurovision will have to operate with possibly only minutes of warning, so that an "alert" system is needed to cope with the situation. It must be appreciated that the relay satellite, orbiting on an elliptical path inclined about 50 degrees to the Equator and at a maximum height of 3,000 miles, will be in a position to handle traffic between America and Europe only when it can "see" both the transmitting and receiving stations. The satellite is expected to have an orbital time of some 100 minutes and it will be in a position to deal with television signals for less than 15 minutes of each orbit. The United States ground station, being built by the American Telephone and Telegraph Company, is at Rumford, Maine.

TIME LAG TROUBLE

This short-period operation of the satellite will be an obvious disadvantage, but first tests are entirely experimental; the main object is to prove the feasibility of an idea. To maintain a continuous transatlantic link, it would be necessary either to launch a whole series of satellites, orbiting in succession, or to launch what is known as a synchronous satellite. This would be put into orbit at a height and speed that would synchronize with the rotation of the earth, so that it would appear to remain stationary. There are considerations that make this an unlikely project of the immediate future because of the necessity of providing the satellite with a method of attitude control and fuel required for small jets to correct any "wander" in its position. The vehicle would also have to be much larger—some 800 lbs. compared with the 150-200 lbs. of the satellites to be used in this year's experiments.

Additionally, the synchronous satellite would require to orbit at something more than 22,000 miles altitude, calling for much higher-powered relay equipment in the space vehicle itself and a great increase in the power of the ground-based transmitters. The increased cost of launching the heavier vehicle is another important factor. There is an incidental disadvantage in the high-altitude orbit; because of the distance between transmitter, satellite and receiver, there will be an appreciable time-delay in the signal which would be unacceptable in normal telephone traffic, though it would not be apparent in television transmissions.

Two types of satellite have been prepared for the NASA experiments. The first is Telstar, manufactured by Bell Telephone Laboratories and the second is Relay, developed by the Radio Corporation of America. It is likely that during this year two of each will be launched, the first possibly next month, but more likely in April. Television relays, however, are unlikely to start before May, following initial experiments with telephone and telegraph traffic.

It is interesting to find that the satellites will not be handling the full bandwidth of the American 525-line 60-cycle pictures, which, in normal American networking, occupy a 4.5 Mc/s channel. The satellite signal will be degraded to a 3.0 Mc/s bandwidth, which means that the existing British coaxial and microwave links will be able to handle the full width of the signal.

The major problem that the combined technical strength of BBC and ITV have to solve is the conversion of the American-type signal for consumption in Europe. The US 525-line transmission must be translated to 405 and 625 lines, and for technical reasons it is impossible to use double-conversion—first converting the picture into 405 lines and then turning the resulting picture into 625 lines—because not only the line structure but the field frequency must be altered. This is the reason why feeding the signal to Europe is going to strain the equipment resources of the British television networks.

One signal will be transmitted to London, changed to 405 lines and rebroadcast on the British network; a second signal will be channeled to the Eurovision outlet at Folkstone and converted to 625-lines.

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Newspapers of May 9, 1962, carried the following story:

Man for the first time has succeeded in shooting a beam of light at the moon and picking up the reflection back on earth, a group of scientists announced Thursday.

Although the red light would have been clearly visible to a man on the moon, the experiment Wednesday night in nearby Lexington apparently went undetected by residents of the earth.

The revolutionary new technique has promise as a means of delivering power over vast distances to orbiting satellites.

Scientists from Massachusetts Institute of Technology fired 13 bursts of red light at a dark smooth area on the moon, then caught the reflection 2 1/2 seconds later with a telescope.

The time lag came because it is about half a million miles round trip to the moon and light travels at approximately 186,000 miles per second.

The experimental team headed by Prof. Louis Smullin of MIT used a ruby crystal device known as an optical maser built by the Raytheon Co.

The word maser is an acronym for "Molecular Amplification by Stimulated Emission Radiation." Optical masers first were developed less than three years ago by Dr. Charles H. Townes, former professor of physics at Columbia University and now provost at MIT.

The maser uses a ruby crystal rod, about six inches long and slightly thicker than a pencil to intensify visible light and give it precise direction.

The light from four powerful lamps is focused on the maser, builds up to a high-energy peak, then is shot out one end of the maser and through a 12-inch telescope.